Individual Event Probabilities

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Outline

Parameters

Bayesian Probability

- Prior Probabilities
- Probability Denisty Function

Example

- Event 3296_18816

Results

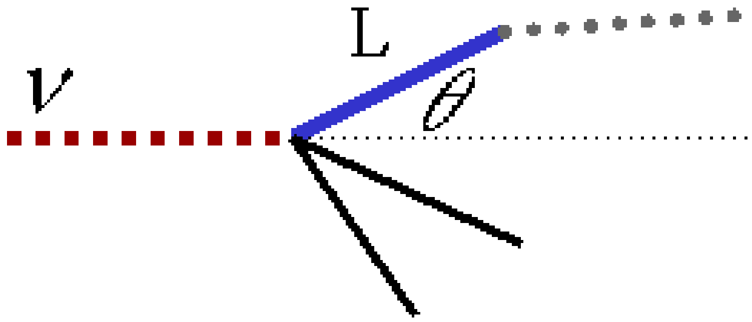
- 3024_30175
- 3039_01910
- 3263_25102
- 3333_17665
- 3334_19920
- 3296_18816

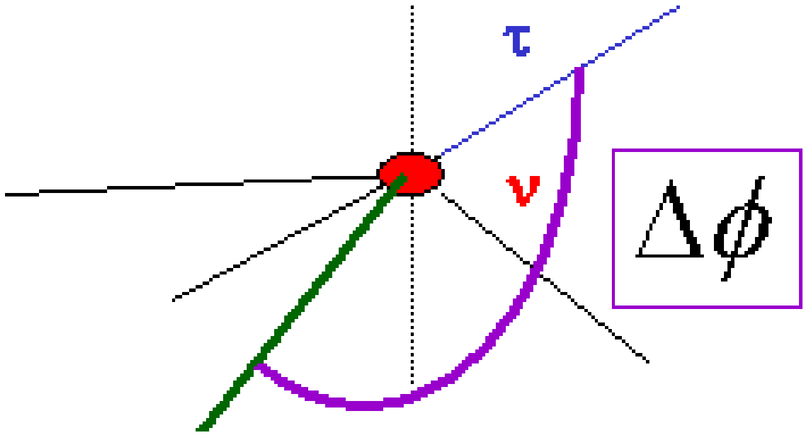
Event 3356_17099

Parameters

Three Parameter Analysis (depends only on the parent track):

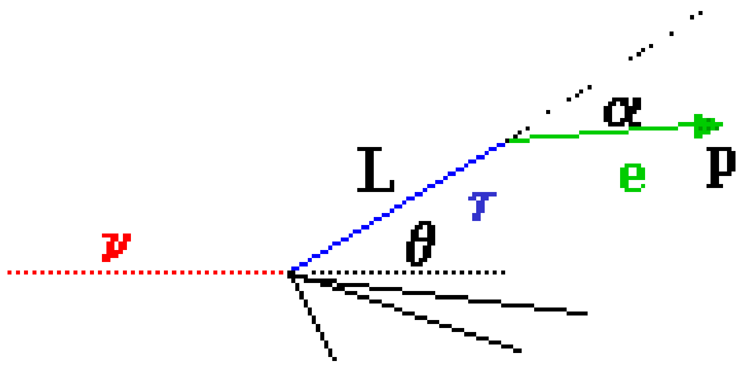
Production Angle θ
Decay Length L
Phi Asymetry $\Delta\phi$





Five Parameter (depends on parent and daughter tracks):

- Phi Assymetry $\Delta\phi$
- Production Angle θ
- Decay Length L
- Daughter Momentum P
- Kink Angle α



Bayesian Probability

$$\mathsf{P}(i) = \frac{[\mathsf{PP}_i][\Pi(i|j)]}{[\mathsf{PP}_i][\Pi(i|j)] + \sum_{\mathsf{bkg}}[\mathsf{PP}_{\mathsf{bkg}}][\Pi(\mathsf{bkg}|j)]}$$

$\mathsf{P}(i)$ = probability event is an i type event, where $i \in$ {tau, charm, scatter}

$\mathsf{PP}(i)$ = prior probabilty
apriori knowlegde of liklihood of event type i

$\Pi(i|j)$ = probability density function
measure of simulated events which reside in a region of parameter space centered around the parameters for the event

Prior Probabilites for Event 3296_18816

$$\mathrm{PP}_i = \frac{N_i P(i \to 3 \text{ prong})\chi}{N_{\text{events}}}$$

where N_i is the expected number of i type events, $P(i \to 3 \text{ prong})$ is the probabilty that the particle will decay/interact to produce 3 charged particles, χ is the probability that the lepton is missed, and N_{events} is the number of events (433).

For tau event, assume 4% of ν interactions are ν_τ:

$$N_\tau = (433)(0.04) = 17.23$$

$$P(\tau \to 3\text{prong}) = 0.1465$$

$$\mathrm{PP}_{\text{tau}} = 5.86\text{x}10^{-3}$$

For charm event:

$$\text{PP}_{charm} = \frac{N_{\text{charm}} P(\text{c} \to 3 \text{ prong})\chi}{N_{\text{events}}}$$

$$N_{\text{charm}} = \sum_i N_{cc} F \alpha_i$$

where $N_{cc} = 295$, the number of charged current events

$F = 0.066$, probabilty that a charged current event gives a charm quark

α_j probability the charm quark will produce a specific charm particle

Particle	α
D	0.24
D_s	0.09
Λ_c	0.10

Particle	N_{charm}	$P(c \to 3)$	χ	PP_{charm}
D	4.67	0.3656	0.3	1.18×10^{-3}
D_s	1.75	0.3234	0.3	3.92×10^{-4}
Λ_c	1.95	0.1988	0.3	2.68×10^{-4}
Total				1.84×10^{-3}

$$\text{PP}_{\text{charm}} = 1.84 \times 10^{-3}$$

For scatter:

$$\text{PP}_{\text{scatter}} = \frac{\sum_i L_i P(\text{interaction}_i)\chi}{N_{\text{scatter}}}$$

Material	Length
Iron	3700 mm
Acrylic	1900 mm
Emulsion	2900 mm

P(interaction $\rightarrow$ 3 prong)/mm	Material
0.00216	Iron
$< 10^{-5}$	Emulsion
$< 10^{-5}$	Acrylic

$\text{PP}_{\text{scatter}} = 5.54\text{x}10^{-3}$ (in iron)
$\text{PP}_{\text{charm}} = 1.84\text{x}10^{-3}$
$\text{PP}_{\text{tau}} = 5.86\text{x}10^{-3}$

Calculating Probability Density Functions for Event 3296_18816

1. Parameters

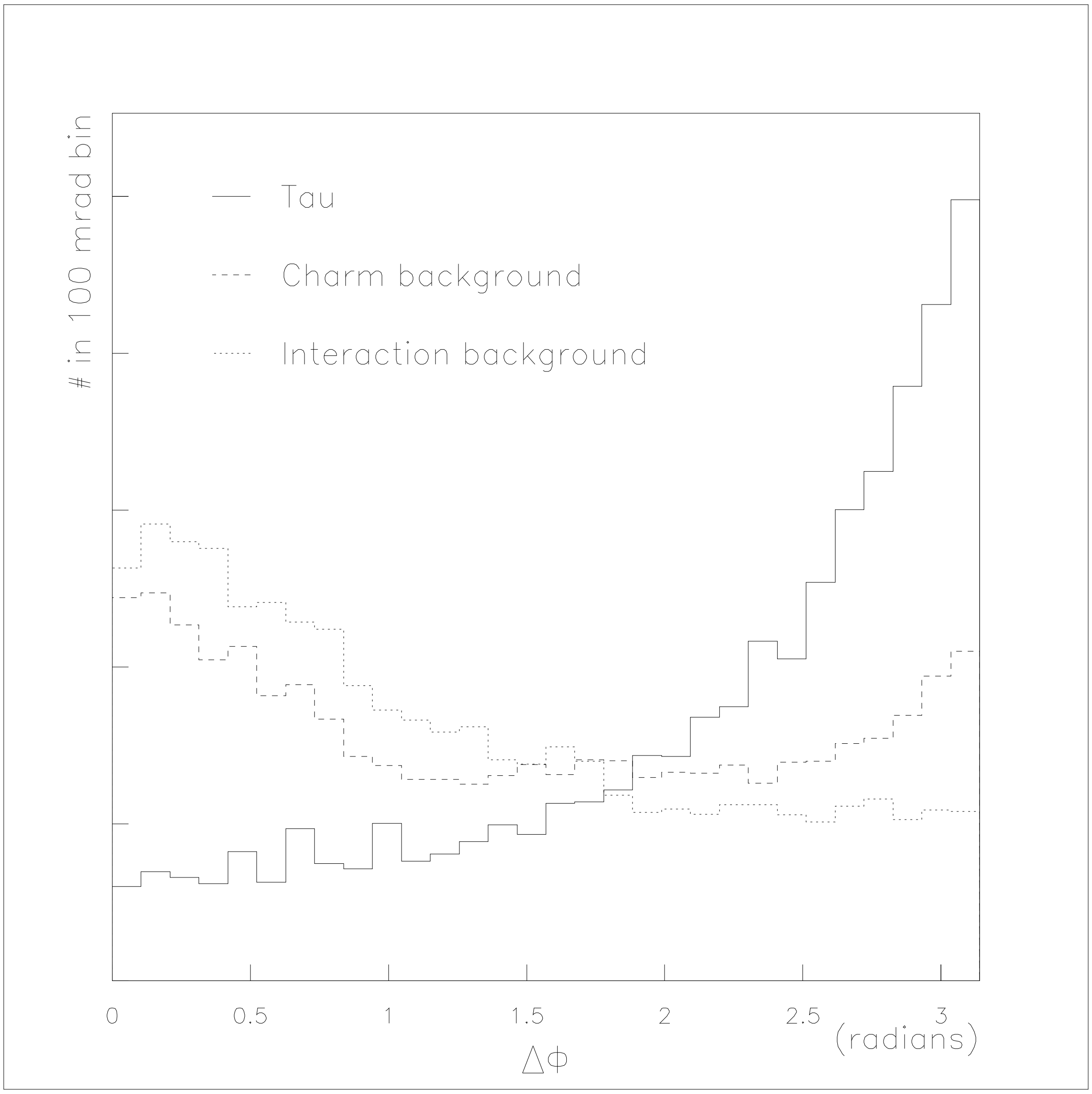
   $\theta = 0.141\text{rad}$
   $\Delta\phi = 1.74\text{rad}$
   $\text{L} = 0.78\text{mm}$

2. Define a volume

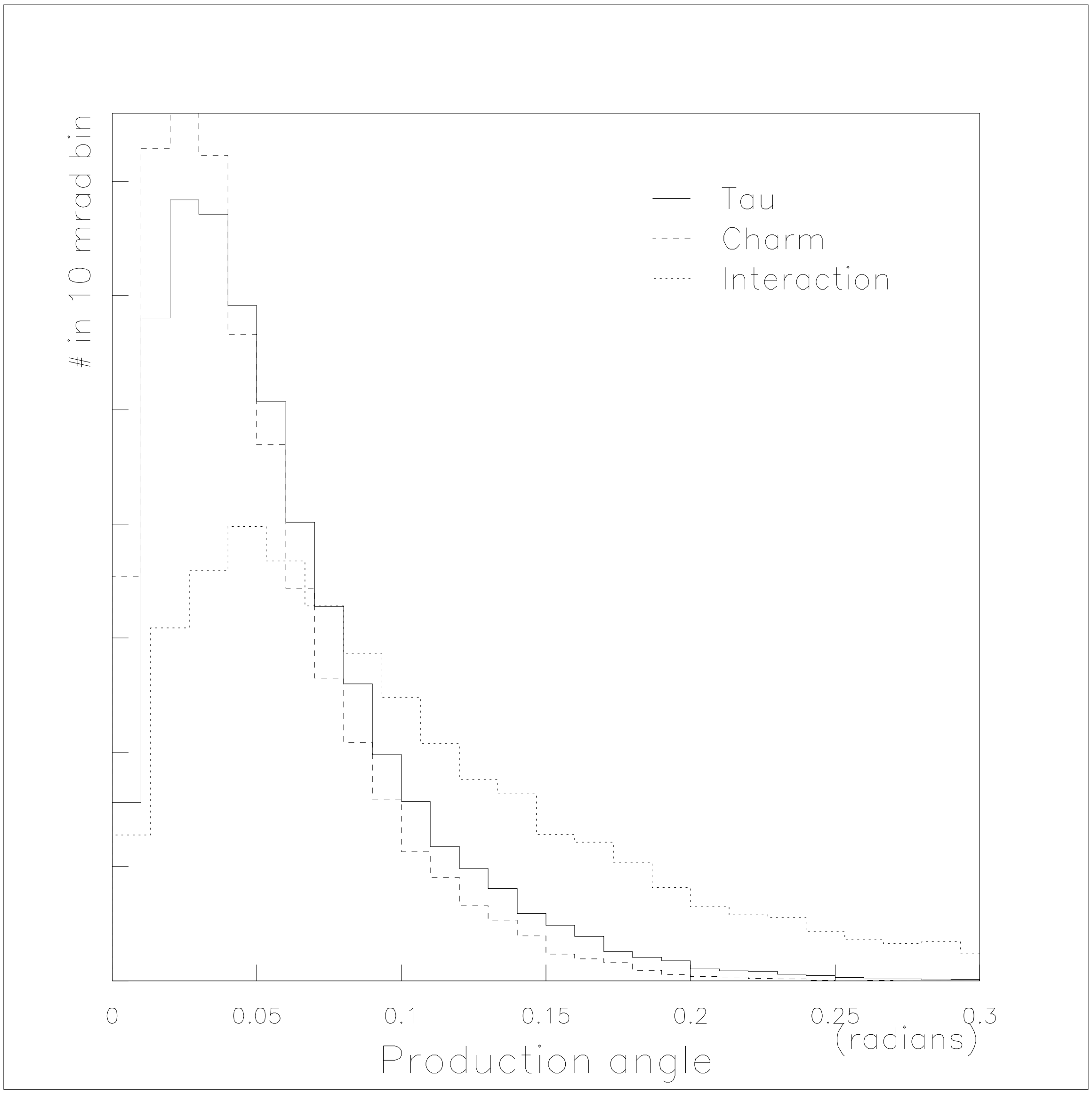
   $\delta\theta = 0.040\text{rad}$
   $\delta(\Delta\phi) = 0.34\text{rad}$
   $\delta\text{L} = 0.10\text{mm}$

3. Calculate fraction of simulated events which fall in this volume: $\theta \pm \delta\theta$ $\Delta\phi \pm \delta(\Delta\phi)$ $\text{L} \pm \delta\text{L}$

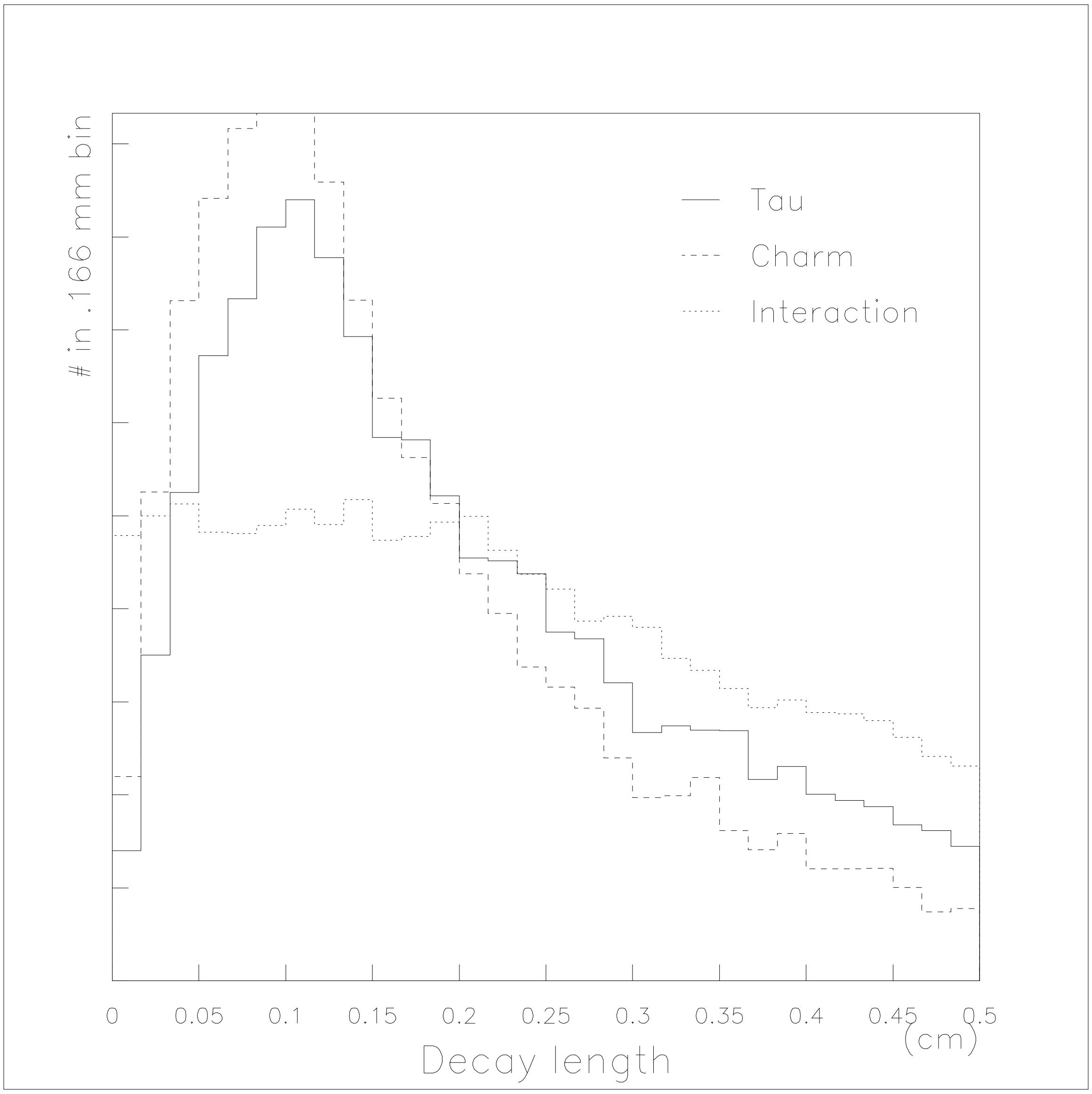
Simulated Event Distribution: Phi Asymetry, $\Delta\phi$



Simulated Event Distribution: Production Angle θ



Simulated Event Distribution: Decay Length



Type	$F_{\theta\phi}$	F_L
Tau	8.54×10^{-4}	1.1×10^{-1}
Charm	1.73×10^{-3}	1.1×10^{-3}
Scatter	4.3×10^{-3}	1.3×10^{-2}

4. Divide by volume to calculate Probabiltiy

   Density (in $\frac{1}{\text{rad}^2\text{mm}}$)

Type	PDF
Tau	0.0863
Charm	0.0035
Scatter	0.0042

5. Calculate probabilities using Bayes's Formula

Type	Probability
Tau	0.89
Charm	0.01
Scatter	0.10

Results for 3 Parameter Analysis

Event	Tau	Probability Charm	Scatter
3024_30175	0.87	0.13	0.00
3039_01910	0.99	0.00	0.00
3263_25102	0.06	0.03	0.91
3333_17665	0.99	0.00	0.00
3334_19920	0.96	0.03	0.01
3296_18816	0.89	0.01	0.10

Comparison

Five Parameter:

Event	Tau	Charm	Scatter
3024_30175	0.62	0.38	0.00
3039_01910	0.93	0.07	0.00
3263_25102	0.15	0.29	0.56
3333_17665	0.99	0.01	0.00

Three Parameter:

Event	Tau	Charm	Scatter
3024_30175	0.87	0.13	0.00
3039_01910	0.99	0.00	0.00
3263_25102	0.06	0.03	0.91
3333_17665	0.99	0.00	0.00

Event 3356_17099

Differences due to short decay:

- No tau track

- Possible muon track

Procedure

- Assume tau track extends to the first emulsion segment in the daughter track, and there is no muon

- Assume tau track extends to the first emulsion segment in the daughter track, and there is a muon

- Assume tau track extends and daughter track meet before the first daughter segment, and there is no muon

- Assume tau track extends and daughter track meet before the first daughter segment, and there is a muon

- Compare results

Results for Event 3356_17099

	full muon	length no muon	half muon	length no muon
P(tau)	0.00	0.02	0.00	0.00
P(charm)	0.82	0.85	0.69	0.70
P(scatter)	0.18	0.13	0.31	0.30